*Planetary Nebulae: an Eye to the Future*
*Proceedings IAU Symposium No. 283, 2011*

*Arturo Manchado, Letizia Stanghellini & Detlef Schönberner, eds.* DOI: 00.0000/X000000000000000X



# Estimating the binary fraction of planetary nebula central stars

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**Abstract.**
During the past 20 years, the idea that non-spherical planetary nebulae (PN) may need a binary or planetary interaction to be shaped was discussed by various authors. It is now generally agreed that the varied morphologies of PN cannot be fully explained solely by single star evolution. Observationally, more binary central stars of planetary nebulae (CSPN) have been discovered, opening new possibilities to understand the connections between binarity and morphology. So far, ≃45 binary CSPN have been detected, most being close systems detected via flux variability. To determine the PN binary fraction, one needs a method to detect wider binaries. We present here recent results obtained with the various techniques described, concentrating on binary infrared excess observations aimed at detecting binaries of any separation.

**Keywords.** techniques: radial velocities, techniques: photometric, (stars:) binaries: general, stars: statistics, (ISM:) planetary nebulae: general

## 1. Introduction

There is no general concensus yet about what shapes planetary nebulae (PNe). The idea that the presence of a stellar or substellar companion is needed to break the spherical symmetry and account for the observed geometries, called the Binary Hypothesis (see De Marco 2009), is still being tested. The fact that 80% of PNe are non-spherical (Jacoby et al. 2010) potentially implies that the proportion of binary central stars of PNe (CSPN) is much larger than current estimates, therefore indicating that PNe could be preferentially created via a binary channel. If the observed fraction of binary CSPN were higher than expected in the current paradigm (35% for binaries with separations < 500 AU), this would support the idea that PNe are preferentially a binary phenomenon. To estimate the binary fraction, we need an unbiased sample of PNe. The determination of whether a CSPN is binary is not trivial and requires a suite of methods, which we describe below. We also present new obervational results and how this constrains the binary fraction. We conclude with some thoughts to refine this value.

## 2. Methods to investigate binarity

We here present the methods used to investigate binarity in our PN sample: flux and spectral variability and infrared (IR) excess, as well as recent results obtained with them.

The binary-induced flux variability method is based on the variation of brightness of the binary system. The three main causes of this flux variability are eclipses, tidal deformations, but mainly irradiation effects from the hot companion onto the cold one create flux changes. This method gives a close binary fraction of about 15-20% (see Bond 2000, Miszalski et al. 2009). It is biased to short periods as the three causes of binary induced flux variation all diminish with increasing separation. It is also biased to intrinsically faint stars to avoid periodic variability caused by stellar winds. Pulsations can also be accountable for flux variation. New discoveries will be possible thanks to Kepler, whose field includes 6 PNe, including Kronberger 61, newly imaged by us in March 2011 (see http://www.gemini.edu/node/11656). Five of the six objects show flux variability (see Douchin et al. these proceedings.)

Spectroscopic variability is used to detect the motion of binary systems around their barycenter. Binaries with periods up to a month could potentially be detected with this method. Intrinsically faint stars, with weak or no wind, are targets of choice. This introduces a bias and imposes serious technical restrictions to obtain a sufficient signal-to-noise ratio, ranking this method down for statistical purposes required in our case. Out of 7 central stars targeted by the VLT/UVES, we found that one, A 14, has a radial velocity (RV) variability confirmed at a $3\sigma$ level. Another 3 central stars are likely to be binaries (Douchin et al., in preparation).

The IR excess technique detects the IR emission from a cool companion using high precision optical and NIR photometry. So far, the detection limit is an M8-type star for intrinsically faint central stars (Mv = 6-8). This technique has the advantage that it is less biased by binary separation. We aim to perform high precision photometry for the entire 2 kpc volume-limited sample of Frew (Frew 2008; Frew & Parker 2007). So far, out of 28 central stars of PNe that were observed in the I-band, we have solidly detected an I-band excess in 3, with another possible 5 detections. The spectral types for the 3 detected companions are likely in the early M regime. We have not yet quantified our survey's bias against fainter companions (Passay et al., in preparation).

## 3. Current and future projects

We are currently analysing additional I and J-band photometry datasets which will provide us a preliminary estimate of the binary fraction (separations less than 500 AU).

In addition, space-based observations such as GAIA have a potential capability to detect the reflex orbital motion of central stars of PNe for binaries with intermediate separations, and the extreme photometric precision of Kepler can be used to gauge how many close binaries have avoided detection in previous ground based surveys (see Douchin et al. these proceedings). Also, future ELTs will have the resolving power and sensitivity to detect companions via AO-enhanced direct imaging at separations of a few AU and larger out to 2 kpc, to provide good complementarity to current methods.

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